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(54) APPARATUS FOR CONTROLLING THE VELOCITY OF MOTION OF A SUPPORTING BEAM, SUCH AS AN EXTENSIBLE MAST, LADDER OR THE LIKE

(71) We, CARL METZ G.M.B.H., a German Company of 75, Karlsruhe-West Watt-Strasse 3, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to apparatus for controlling the velocity of motion of a supporting beam, such as the ladder nest of an extensible turntable ladder, the telescopic mast of a telesoter or of a longitudinally adjustable crane arm, the length and position of which are variable in space, in response to the tilting moment produced by the instantaneous values of the length of the supporting beam, the inclination of the supporting beam and a supplementary weight loading the supporting beam.

First known apparatus for the control of extensible ladders will now be described. This known apparatus is capable of providing a stepped as well as a stepless variation in the speed of motion of the ladder. The apparatus employs electromechanical means associated with a servomotor, the motion of which is transmitted directly to a rotary valve by means of which the hydraulic system for the drive of any one of the movement functions of the ladder is actuated. However, this apparatus, constructed as remote control system, does not operate relative to the tilting moment which is defined by the instantaneous values of supporting beam length, supporting beam inclination and a supplementary weight which loads the said supporting beam. Such a dependence on a prevailing instantaneous condition is however of fundamental significance, in particular for extensible ladders or the like, as will be explained hereinbelow.

A power-driven mobile turntable ladder, in particular when constructed as emergency rescue apparatus or to be used as such, must be capable of performing its setting motions in the shortest possible time in the same way as a telescopic mast telesoter, that is to say, in the interests of the most rapid and safe possible rescue of persons and materials from an emergency condition, its erecting and extension motion as well as the pivoting motions must be capable of being performed at the highest possible permissible speed. Different static and dynamic force and load conditions will always occur under these conditions. It is a known fact that a supporting arm, irrespective of whether it is the ladder nest of a turntable ladder or the telescopic mast of a telesoter or an extensible crane jib at any instantaneous state of extension and subject to the manner of its support, for example by means of a supporting frame which may preferably be the chassis of the supporting vehicle, has a tilting motion imposed upon it if a certain tilting moment is exceeded. In apparatus of the kind heretofore described such tilting moment depends fundamentally on the moment of the overall centre of gravity of the ladder nest (or telescopic mast or crane arm) about its hinging position on the supporting frame which in turn is defined by the mass distribution due to the ladder nest construction and relating to the ladder length in the appropriate extended state and the magnitude of the appropriate supplementary load and the point at which it cast, such load referring to the number of persons and the position of persons disposed on the ladder or on the load of a working cage mounted on the ladder end. If the maximum permissible tilting moment is reached in relation to the aforementioned quantities, the supporting frame and the ladder nest or telescopic mast or crane arm construction supported thereby is in danger of toppling. This will occur even if the loading acting on the supporting arm (ladder nest or telescopic mast or extensible crane arm) is purely static. It is therefore necessary to avoid this. If the supporting arm motions performed at the greatest pos-

sible speed therefore approach a zone in which, due to loadings acting on the supporting arm, an instantaneous tilting moment is reached which is near the maximum permissible tilting moment, the speed of such motion in known constructions of apparatus of the kind hereinbefore described is changed so that the said speed of the aforementioned motion is suddenly lowered from a larger value to a lower value. The sudden reduction to a lower speed results in an accelerating force acting on the supporting arm, such accelerating force involving two substantial risks. On the one hand, and in particular if the appropriate motion or motions are traversed at the maximum permissible speed and if this speed is furthermore utilised for as long as possible in order to move the supporting arm in the shortest possible time into the desired position, this may result in stresses acting on the supporting arm structure, the said stresses being so large as to result in the said supporting arm being damaged. No remedy is possible by any reinforcement based on the design or the strength of the material of the supporting arm since this is, in all cases, accompanied by an increase of weight which on the one hand and in turn would have a detrimental effect on the maximum permissible speed limit and would moreover have an unfavourable effect on the maximum permissible tilting moment in the sense that the ladder length and angle of inclination or angle of pivoting would deteriorate in the sense of a reduction of the zone of effective use. Moreover, the same effects also act directly on the tilting moment, namely by producing a moment component which mav be described as dynamic tilting moment. Depending on the kind of the motion which is just being decelerated and depending on the magnitude and in particular on the direction of the accelerating forces produced by the deceleration it is possible for a dynamic tilting moment to occur in the same sense as the static tilting moment so that the entirely comprising the supporting frame and the supporting arm, that is to say for example the vehicle chassis and the ladder mount supported thereby, is stressed beyond the permissible tilting moment although the static maximum permissible tilting moment has not yet been reached.

As a consequence of the acceleration forces which thus occur and which become the greater the more the ladder in its particular state of loading approaches its permissible tilting moment and the greater the changes of velocity, it is furthermore possible for the inertia forces which thus occur, to cause vibration of the ladder, a feature which in turn involves substantial disadvantages. In particular this may be the case if a working or rescue cage is disposed in usual manner on the ladder end containing persons which are transferred from the hazard zone to the ground in so-called ferry operation so that the persons (or goods) disposed in the ladder cage may be placed at risk.

A second known apparatus, which is for use with lorry-mounted turntable extensible ladders comprises a control system associated with a control element which automatically influences one or more drives for the extension, erection and pivoting motions of the ladder so that the velocity of the individual motions is increasingly reduced according to the degree to which the vehicle is stressed in tilting by the centre of gravity of the ladder. In this known automatically operating system the control element comprises a plurality of pilot control units, operated relative to the appropriate ladder motions, and of one or more regulating elements which in turn are actuated by the control elements and which influence the drives for the ladder motions in a regulating manner. In such a syste mthe pilot control element comprises a rope drum which is mechanically coupled to the extension apparatus for the ladder and whose rope length, payed off from the rope drum, is proportional to the length of the extended ladder. To this end, one shaft disposed in the rope drum is coupled to a driving shaft of the regulating element. The said regulating element is disposed in a hydraulic circuit which acts on a hydraulic cylinder functioning as mechanism for erecting and inclining the ladder. The velocity of extending the ladder nest may be regulated by means of this known apparatus relative of the position of said ladder nest in space but without reference to the instantaneous loading of the supporting beam.

The velocities of the ladder motions in this known control system may also be simultaneously dependent on the angle of inclination of the ladder, of its extension length, of the pivoting angle of the ladder so that not only the velocity of inclining and erecting but also the slewing velocity and the velocity of lateral vertical positioning may also be controlled relative to the aforementioned quantities. In the known control system this effect is achieved by the measured values of two instantaneous motional quantities which are transmitted through a measured value transducer to a weighing beam while a given superimposition of the third motional quantity is fed as constant value into one of the aforementioned measured value transducers, the instantaneous value of the extension length of the ladder being one measured value in the known system the other measured value being the instantaneous value of inclination of the ladder relative to the horizontal. In this known system, the ladder weight, and where appropriate the relationship between the tilting moment and the lateral vertical

positioning of the ladder, are predefined as constant factors due to the so-called level compensation. However, this means that a turntable ladder equipped with such a known control system must suffer from a very substantial disadvantage. If the effect of the weight loading on the ladder is supplied as predefined value to the aforementioned control system, the means that the said weight value, comprising the constant ladder nest weight which is always present and the weight of the loading of the ladder which varies in operation, must always be constant. This however means that the variable supplementary weight in the form of the maximum permissible load weight must be incorporated into the fixedly defined weight value. This quantity may be very substantial, in particular in the case of turntable ladders or telescopic mast telesoters intended for use in emergency rescue vehicles. With reference to the possibility of performing the individual motions of such apparatus as rapidly as possible it means that at the time at which the motional quantity of such apparatus, substantially co-defining the instantaneous tilting moment, namely the instantaneous weight loading is fed to the control system with the value corresponding to maximum loading in the sense of a simulation, namely in an operating state in which such a weight loading of the ladder nest does not occur at all and the known control system must necessarily react so that all motions are performed fundamentally at a velocity which would apply if the maximum possible supplementary weight were present. In other words, this means that the maximum permissible velocity for performing the individual motions of apparatus provided with such a known control system is already limited to a defined value which is lower than that corresponding to the actual loading condition of the ladder (or of the telescopic mast or of the extensible crane arm).

Owing to its construction and method of operation the known control system also suffers from another important disadvantage. This is due to the fact that the known control system is actuated relative to the ladder motion or motions in such a way that in the event of an increase of the tilting moment caused by the centre of gravity of the ladder and acting on to the ladder vehicle the flow of pressure medium in the affected control circuit runs is restricted for the individual motions of the ladder. This means however that even if the unloaded ladder nest is extended the maximum velocity in the sense of a speed-reducing signal acting on all motions is reduced constantly and progressively in accordance with the measured value of the extended length as supplied to the known control system. Expressed in other words this means that the maximum possible velocity is constantly reduced in accordance with the prevailing operation of the ladder without there being any necessity for doing so in terms of the applied tilting moment. In such a system, the known control means are constructed so that when the maximum tilting torque is reached as a consequence of performing any one motion, the motional velocity is necessarily reduced to a disappearing value because the maximum possible velocity defining the actual velocity values of the main control system for the individual motions in the sense of a superimposed signal assumes its disappearing value under conditions of a maximum permissible tilting moment.

This known control system, which does not represent a remote control system, offers an advantage relative to a further known kind of control with facilities for remote control of a turntable ladder, a telescopic mast telesoter or of an extensible crane arm but it differs relative to this further known control system, which will be described hereinbelow by virtue of other important disadvantages.

The method of operation of the other known control system is such that the instantaneous value of the tilting moment is measured by measuring apparatus, constructed, for example, as a limit switch, and a pulse, corresponding to such value, is transmitted to a hydraulic system by means of which a separate restrictor, disposed in the hydraulic control circuits for the individual motions of the ladder, is suddenly operated so that the flow of hydraulic fluid in the aforementioned control circuits for these motions is reduced in the sense of reducing the motional velocities. This other known control system will then permitt individual operation or velocity control of the individual motions by operation of the main control unit with the consequence that the individual motions proceed in the same manner in which the motions were controlled by means of the main control unit in accordance with the choice of the operator prior to reaching the predefined instantaneous value of the tilting torque but with the exception that after the aforementioned and predefined instantaneous tilting torque is exceeded, the velocity of the motions controlled in this manner corresponds only to a predefined fraction of the maximum initial velocity and corresponding to the restrictor position of the engaged flow restrictors in the individual hydraulic control circuits.

When the maximum permissible tilting moment is reached in this other known control system, a further pulse is transmitted to the hydraulic auxiliary control system, by means of which pulse the flow restrictors, incorporated for the motions in the hydraulic control circuits, are each set into the flow blocking position so that all motions are stopped. Because of the necessity of re-extend-

ing the ladder on each occasion from the range of maximum permissible torque, this control system has the facility, by transmitting a further pulse, to once again release the operation of the hydraulic control circuit for the extending and retracting motion of the ladder, but only in the sense of retracting the ladder. If retraction of the ladder so changes the tilting moment conditions that the actual instantaneous tilting moment is below the maximum permissible tilting moment, the blockage will be released by the tilting moment measuring transducer through appropriate pulses supplied to the hydraulic auxiliary control element and the flow restrictors, disposed in the hydraulic working circuits for the various motions of the ladder are returned into the position corresponding to the prevailing instantaneous tilting moment, that is to say into the restrictor position corresponding to a reduction of the maximum possible velocity if the instantaneous tilting moment then attained through the appropriate retraction motion is between the predefined tilting moment value and the maximum permissible tilting moment and into the position corresponding to the maximum possible velocity signal if the instantaneous tilting moment is below the predefined tilting moment value.

If this other known control system is to be employed as remote control system, a main flow restrictor, acting on all hydraulic working circuits for the individual motions of the ladder, supplies a signal corresponding to a reduction of the maximum possible velocity by a defined amount.

When the main restrictor is engaged, the control system will operate as before but with the maximum possible velocity correspondingly reduced, with respect to time, and in the ratio of the hydraulic pressure medium flow rates, with the main flow restrictor disengaged and engaged, respectively.

According to the present invention there is provided apparatus for controlling the velocity of motion of a supporting beam, such as the ladder nest of an extensible turntable ladder, the extensible mast of a telesoter or of a longitudinally adjustable crane arm, the length and position of which are variable in space, in response to the tilting moment produced by the instantaneous values of the length of the supporting beam, the inclination of the supporting beam and a supplementary weight loading the supporting beam, in such a manner that in operation of the supporting beam, when a predefined value of the tilting moment is reached, a first predefined value of the maximum possible velocity of at least one of the motions changing the length or the position of the supporting beam in space is increased or decreased to a second predefined maximum possible velocity value in dependence upon the direction of motion of the supporting beam, to cause a decrease or an increase in the tilting moment of the supporting beam, the transition from said first to said second predefined value of velocity being performed in a predefined time interval, the momentary velocity of the supporting beam being adjustable at will between zero velocity and the existing maximum possible velocity value.

Means may be provided to vary a pulse for operating a means for driving the beam for at least one motion of the supporting beam in response to the attainment of a predefined value of the tilting movement. Such means may be so constructed that after a predefined value of the tilting moment has been reached, the velocity for setting up further motion of the supporting beam is lower than the maximum possible velocity.

" Setting up motion " as used herein comprises, the erecting, extensible or rotary motions of the beam.

Means may be provided to prevent one or more operating pulses from being fed to the driving means for one or more of said motions to operate such driving means in a sense to increase the tilting moment when a predefined tilting moment value is reached. Means may be provided to permit one or more operating pulses for the driving means to be fed thereto when a predefined tilting moment which is lower than the maximum permissible tilting moment has been reached so that the restoring motions of the supporting beam can proceed at a velocity which corresponds to the maximum possible velocity.

" Restoring motion " as used herein comprises the lowering, retractile or rotary motion of the beam, this last being in the opposite sense to the rotary setting up motion.

The apparatus may include a measured value transducer which provides a pulse to control the means for varying the operating pulses, the characteristics of the control pulse depending on the instantaneous value of the supporting beam length, the supporting arm inclination and the supplementary weight acting on the supporting beam.

For the case where the supporting beam is located on sloping ground, the control pulse may depend on the angular position of the supporting beam relative to an axis perpendicular to the axis for said inclination of the supporting beam, the transducer being preferably constructed as a tilting moment balance. The means for varying the operating pulses for the driving means may depend upon at least two control pulses and one of the control pulses may exist from the attainment of the predefined tilting moment up to the attainment of the maximum permissible value of the tilting moment, another control pulse existing up to a value just below such maximum permissible value.

The pulses may be of any suitable form.

Electric fluid, hydraulic or peumatic energy may be used as pulse carrying medium. The channels may also be radio transmission channels, for example.

In the interest of simplicity, the means for varying the operating pulse(s) for the driving means may be so constructed that the velocity of the restoring motions of the supporting beam can be changed from zero to the maximum possible value and vice versa for setting up the motions of the supporting beam when a control pulse which is associated with a momentary tilting moment which is lower than the maximum permissible tilting moment is supplied thereto. The means for varying the operating pulse for the driving means may be so constructed that the motional velocity of the supporting beam can be changed from zero to a first predetermined value, which is lower than the maximum permissible value, and vice versa, if both a first control pulse associated with a first momentary value of the tilting moment below the maximum permissible tilting moment and a second control pulse associated with a second momentary value of the tilting moment between the first predetermined tilting moment value and the maximum permissible tilting moment are supplied thereto. It is further possible for the means for varying the operating pulse for the driving means to be so constructed that if only one control pulse associated with an instantaneous tilting moment value between the predetermined tilting moment and the maximum permissible tilting moment is supplied the velocity can be automatically changed from zero value to a higher preset value which is proportional to the maximum velocity.

Conveniently, the means for varying the operating pulse for the driving means is constructed so that if only one control pulse associated with an instantaneous tilting moment value between the predefined tilting moment and the maximum permissible tilting moment is supplied, the velocity can be automatically changed from zero value to a preset value which is proportional to the maximum possible velocity value.

Further, the means for varying the operating pulse for the driving means may be provided with a signalling unit, a pilot control unit and a main control unit, such units being operable under the control of the measured value transducer. This permits the apparatus to be embodied in unit construction form. Each unit may be constructed as a sub-assembly. Such sub-assembly units may be independent of one another as regards pulse transmission between them and the individual units may be so constructed, in accordance with the technical requirements that the units operate with different pulse transmitting media or energy media.

For example it may be necessary or useful for the signalling unit to be operated with one kind of energy, for example electric or hydraulic energy, while the pilot control unit is operated mechanically or hydromotrically or electromotrically. An electric or a hydraulic construction is suitable for the main control unit since such a unit can act directly through suitable pulses on the driving means for the individual motions of the supporting beam. In cases where the supporting equipment e.g. crane operates mainly with compressed air the use of pneumatic energy may be appropriate, in particular for the main control unit. However, where great lengths must be bridged between the pilot control until and the main control unit electrical energy may be more suitable as the pulse transmission medium if the two units are appropriately constructed, radio pulse transmission offering advantages in particular if the two units are to be interlinked.

According to a preferred embodiment of the invention the signalling unit includes a control circuit for at least one switching element which is associated with the pilot control unit, has been found to be particularly appropriate. The signalling unit may be constructed to respond to fluidic, pneumatic, hydraulic or electric pulses. Also, the signalling unit may be responsive to several kinds of such pulses. Similarly it is also possible for the pilot control unit and the main control unit to be responsive to pulses which are transmitted by the aforementioned carrier energies. The signalling unit may be provided with relays which may be operable in response to the control pulses. To this end the signalling unit may have relays constructed as NC or NO contact units. The term "relay" may refer in this context not only to mechanically operating elements or electromechanically operating components or switching elements for fluid, pneumatic or hydraulic energies but also to electronic components as for example electronic valves or semiconductor components, in particular controllable semiconductors and in particular thyristors.

According to a preferred embodiment of the invention at least five relays are provided, interlinked by electric current paths.

The signalling unit may have a first relay the contact of which is in a pulse conductor for said first control pulse, such pulse conductor branching into two parts downstream of the contact of said first relay, the relay coils of a second and a third relay each being disposed in one of said parts, the contact of said second and third relays being serially connected in a first supply conductor for the supply of the first control pulse to a drive means of the pilot control unit, the contact of the first relay being in a pulse conductor for said second control pulse, the contacts of the second and third relays being also serially

connected in a second supply conductor for the supply of the second control pulse to the drive means of the pilot control unit.

This construction of the signalling unit provides pulse conductor paths of particularly short lengths and with a relatively simple construction of the individual relays.

The first relay may be so constructed that in the absence of the second control pulse the contact of the first relay provides free passage for the pulse switched by such contact as part of the pulse conductor for the first control pulse while the second and third relays are so constructed that their contacts provide free passage as part of the first supply conductor and for the pulses switched by the such contacts if the first control pulse is present and in the absence of the first control pulse and are closed in their function as parts of the second supply conductor, the first control pulse being directly supplied to the contact for the switched pulse of the second relay and the second control pulse being directly supplied to the contact for the switched pulse of the third relay.

According to a further advantageous embodiment of the invention the signalling unit may have a fourth relay the coil of which forms part of a pulse conductor bridging the coils of the second and third relays for the first control pulse and the contact of which is disposed downstream of the contact of the second relay, the said fourth relay being so constructed, that in the absence of the first control pulse the contact of the fourth relay provides free passage for the second control pulse.

According to a further embodiment the signalling unit has a fifth relay the coil of which is part of the pulse conductor bridging coils of the second and third relays, the contact of the fifth relay being connected in a pulse conductor for the first control pulse, bridging the contact of the first relay and being connected to the coils of the second and third relays, the fifth relay being so constructed that when the first control pulse is supplied as a switching pulse the contact of the fifth relay provides free passage for the first control pulse.

Preferably, the pilot control unit is supplied through at least one supply conductor, from said signalling unit with at least one driving control pulse related to the supply of said first control pulse and/or said second control pulse. To this end, the first and/or said second control pulse may be supplied in directionally modified form and as driving pulses to the drive means in response to the supply of the first and/or second control pulse to the signalling unit. Compared with another embodiment in which the drive means of the pilot control unit is supplied with other control pulses as driving control pulses, this embodiment offers the advantage of particularly simple construction due to the passage of the control pulse through the signalling unit accompanied merely by directional modification if the signalling unit and the pilot control unit operate with the same kind of energy. Where the pulse carrier energies for the signalling unit and the pilot control unit are different, the control pulse supplied to the signalling unit as a driving control pulse is not excluded for the drive means of the pilot control unit but will be less suitable in most cases.

In cases in which the operating element of the pilot control unit is operated by independent external energy, for example if it is constructed as an electric motor driven from a battery, it may be appropriate for the driving control pulse to be supplied to an energy switching element which is disposed in an energy conductor connecting the drive means of the pilot control unit with an energy source and by means of which the supply of energy can be released or blocked in response to the supply of the driving control pulse. In cases where the signalling unit and the pilot control unit operate with the same kind of energy it may be particularly appropriate for reasons of a space-saving and weight-saving for the operating energy to be supplied to the drive means of the pilot control unit through its driving control pulse. However, the signalling unit need not necessarily operate with pulses having a high energy content. Driving control pulses of sufficient energy content for the drive means of the pilot control unit may be formed by suitable amplifying means which may be adapted to the energy or pulse carrier medium used in the signalling unit for the direct supply to the aforementioned pilot control unit.

The pilot control unit may have a control circuit which can be supplied with a driving control pulse as starting pulse for the operating element, the control circuit having switch means which are automatically operated by the pilot control unit and by means of which drive means of that unit can be switched off in accordance with a predetermined time plan. To this end the switch means may comprise at least four switching elements. Said switching elements may be operated by means of a switching pulse derived from a programme transmitter actuable by the drive means of the pilot control unit.

Advantageously, a first switching element of said switch means has a switch contact forming part of the supply conductor for a first said driving control pulse and being connected downstream of the contact of the third relay of the signalling unit, the said first switching element being so constructed, that if a driving control pulse is supplied to the drive means relative to the supply of the said first control pulse to the signalling unit, the

switch contact of the first switching element is opened.

Said switch means may comprises a second switching element having a switch contact forming part of a conductor for a second said driving control pulse and being connected downstream of the contact of the second relay of the signalling unit, said second switching element being so constructed that, if driving pulses are supplied to the said drive means, the switch contact of said second switching element is closed, and, if the drive motor is actuated, can be brought into the pulse-conducting state in accordance with a predefined time plan, relative to a driving pulse being supplied to the signalling unit and depending on the supply of only the second control pulse.

Said switch means may comprise a third and/or fourth switching element switchable relative to a given time plan.

In a particularly simple further construction the pilot control unit is provided with a programme transmitter, being actively associated with at least one switching-off element, and being constructed as a run up cam, the position of which is variable by the drive means of the pilot control unit relative to the aforementioned switching-off element. To this end, the programme transmitter may be advantageously constructed as a cam member the position of which can be varied in response to the actuation of such drive means. Where the switching-off element(s) is fixedly mounted the cam member forming the programme transmitter may be exchangeable for resetting the time sequence programme of the apparatus. In particular, the position of the switching element or elements in active association with the programme transmitter may be variable relative thereto for the purpose of re-adjustment and adaptation to wear.

According to a simple and preferred embodiment of the invention, the pilot control unit is provided with a programme transmitter constructed as a translatory slidable cam disc having a cam contour which is actively associated with the third and fourth switching elements and has run-up cams, the third and fourth switching elements being constructed as run-off switches with a sensing element traversing the cam contour of the cam disc and the first and second switching elements being constructed as limit switches operable by contact with the associated run-up cams.

Although the programme transmitter may also be operated indirectly in response to the actuation of the drive means of the pilot control unit the drive means may be a drive motor for driving the programme transmitter. The programme transmitter may be operable through a spindle of said motor which is an electric motor.

The main control unit may comprise a plurality of independent main control circuits for example three such main control circuits, corresponding to the number of motions of the supporting beam whose length and position in space are variable, by means of which control circuits a starting pulse a further and a switching-off pulse can be supplied in in accordance with requirements to the driving means for the appropriate motion of the supporting beam, the said main control circuits having a common supplementary control circuit associated therewith, by means of which and in the event that a predefined tilting moment value is reached, a supplementary control pulse formed relative to the operation of the pilot control unit, can be superimposed on at least one of the main control circuits so that the velocity of the motion associated with one or more of said control circuits is reduced from a higher value to a lower pre-set value of said maximum velocity.

A first main control circuit may be associated with the erecting motion of the supporting beam, a second main control circuit being associated with the slewing motion of the supporting beam about a vertical slewing axis and a third main control circuit being associated with the change of length motion of the supporting beam, the supplementary pulse being super-imposable on the first second main control circuits in the sense of both directions of motion and can be superimposed on the third main control circuit only in the sense of an extension of the supporting beam. This construction ensures that whenever the supporting beam is subject to a tilting moment state which corresponds to the maximum permissible tilting moment which would normally call for blockage of all motions, the return of the supporting beam into a range below the maximum permissible tilting moment by retraction of the extension length of the supporting beam is always possible and that moreover the said return can be performed with the maximum possible velocity (maximum speed signal) since no reduction of the speed signal comes into action for a retraction motion.

Each main control circuit may have two control elements, one of which can vary the operating pulse for the driving means for the associated motion of the supporting beam in the sense of varying the velocity of said motion from a disappearing value to a maximum value and vice versa in one motional direction and the other control element being capable of varying the said operating pulse to vary the velocity of said motion from a disappearing value to a maximum value and vice versa in the other motional direction.

In the interest of economy, the control elements of the first and second main control circuits may be provided with a common terminal and the control element of the third

main control circuit for increasing the length of the supporting beam is provided with a first terminal and the control element of the third main control circuit for reducing the length of the supporting beam is provided with a second terminal, the terminals of the first and second main control circuit and the first terminal of the third main control circuit being connected to each other through pulse conductors and furthermore through a pulse access conductor to the pilot control unit while the second terminal of the third main control circuit is directly connected to the pulse energy source.

It has also been found advantageous for the supplementary control circuit to be provided with a control element by means of which the supplementary pulse can be superimposed on the main control circuits so that while the control facilities of the main control circuits are maintained, the operating pulses for the driving means of the supporting beam motions which can be influenced by the supplementary pulse can be varied to a value corresponding to a fraction or a multiple of the velocity value associated with an instantaneous tilting moment value below a predefined tilting moment. To this end it is advantageous for the control element of the supplementary control circuit to be actuated in response to the operation of the pilot control unit. An embodiment in which the control element of the supplementary control circuit can be operated in response to the operation of the programme transmitter of the pilot control unit has been found particularly advantageous.

The control element of the supplementary control circuit may be operated by the programme transmitter of the pilot control unit.

The supplementary control circuit may be provided with a switching element which is so constructed that, in the event of a change in the supplementary pulse in the sense of a reduction in the supporting beam velocity to the lower maximum velocity limit and following the supply to the signalling unit of a pulse corresponding to an instantaneous tilting moment value, which in turn corresponds to the maximum tilting moment value, such switching element blocks the supply of energy to the driving means for the motions of the supporting beam, said driving means being associated with the main control circuits which are influenced by such switching element.

For a better understanding of the invention reference will now be made by way of example to the accompanying drawings in which:—

Figure 1 is a diagrammatic side view of a power driven turntable ladder mounted on a motor vehicle and comprising apparatus according to the invention;

Figure 2 is a schematic circuit diagram of a control system for the apparatus, such system comprising a signalling unit, a pilot control unit and a main control unit;

Figure 3 is a block schematic circuit diagram showing pulse conductors and associated switching elements of the pilot control unit; and

Figure 4 is a graph showing characteristics of maximum possible velocities (velocity signals) plotted against tilting moment in said first and second known control systems and in the apparatus according to the invention shown in the drawings for direction control on driving means for supporting beam motions, in the case of manual and remote control operation.

Parts corresponding to each other are provided with the same reference symbols.

As shown in Figure 1, a ladder nest 10 which is referred to hereinafter as a supporting beam in the interest of simplicity, is mounted on a motor vehicle 7 and can be luffed by means of the luffing mount 9 about a horizontal axis 11 supported in a slewing tower 8. The angle of inclination of the supporting beam 10 obtained by luffing it about the axis 11 will be referred to as the single "alpha". The slewing tower 8 can be pivoted about a vertical axis B. A pin 14 which is rotatable about an axis A through an angle "beta" is provided adjusting the level of the beam 10. The instantaneous length of the beam 10 is referenced L supplementary weight G acts in the direction of the arrow referenced G. A measured value transducer 13 is disposed in the slewing tower 8 and is adapted continuously to supply pulses corresponding to the tilting moment of the supporting beam, from a tilting moment balance.

Figure 2 shows the association of the individual units of the system and their interconnecting circuit, each unit being shown within a dot-dash frame. In Figure 2 the main control unit is referenced 1, a signalling unit 2, a pilot control unit 3, a driving unit 4, and a signal indicator 5. The main control unit 1 has a first main control circuit 140 for the erecting motion of the supporting beam 10, a second main control circuit 150 for the slewing motion of the supporting beam 10 about a vertical axis of rotation B and a third main control circuit 160 for the changing of length motion L of the supporting beam 10. Each main control circuit 140 or 150 or 160 respectively is provided with two control elements 111, 112, or 113, 114 or 115, 116. The control elements 111 or 113 or 115 respectively are provided to vary the operating pulses I-401 to I-406 for the driving unit 4 in relation to the associated motion of the supporting beam 10 in the sense of varying the velocity of said motion from a disappearing value to a maximum value and vice versa in one direction of movement and the control elements 112 or

114 or 116 respectively are provided to vary the correspondingly associated operating pulses I-401 to I-406 in the sense of changing the velocity of the motion from a disappearing value to a maximum value and vice versa in the other direction of movement. A common tapping 141 or 151 respectively is associated with the control elements 111, 112 or 113, 114 of the first and second control circuit 140 and 150 respectively. The control element 115 of the third main control circuit 160 associated with increasing the supporting beam length L, is associated with a first tapping 161 and the control element 116 of the third control circuit 160, provided for reducing the supporting beam length L, is associated with a second tapping 162. The tappings 141 and 151 of the first and second main control circuits 140 and 150 respectively and the first tapipng 161 of the third main control circuit 160 are connected to each other through pulse conductors at *d* and furthermore through a supplementary control circuit 170 to the pilot control unit 3 while the second tapping 162 of the third main control circuit 160 is directly connected to the impulse energy source I-603. The numerals 121 to 126 refer to contact elements which are disposed in the corresponding main control circuits 140 to 160.

The main control unit 1 therefore has a number of independent main control circuits 140, 150 and 160, corresponding to the number of motions and by means of which and in accordance with requirements the appropriate driving means 401, 407, 404 or 402, 408, 405 or 403, 409, 406 of the driving unit 4 for the appropriate motion of the supporting beam 10 are each supplied with the starting pulse I-401 to I-406, a pulse I-111 or I-112 or I-113 or I-114 or I-115 or I-116 for defining the velocity of the motion and the switching-off pulse I-121 or I-122 or I-123 or I-124 or I-125 or I-126. The aforementioned main control circuits 140, 150 and 160 have a common supplementary control circuit 170 associated therewith by means of which and on attainment of a predefined tilting moment value a supplementary pulse I-170 may be superimposed on at least one of the main control circuits 140 or 150 or 160 respectively relative to the operation of the pilot control unit 3 so that the velocity of the motion associated with at least the aforementioned main control circuit 140 or 150 or 160 can be forcibly varied to a predefined value.

The signalling unit 2, responding to electrical pulses I-601 and I-602 in accordance with this embodiment of the invention advantageously comprises five control circuits 201 to 205, each of which have a switching element R1 to R5. In this case the switching elements R1 to R5 consist of relays responsive to the control pulses I-601 and I-602. The relays R1 to R5 have contacts R1′ to R5′, respectively. The relays may be correspondingly constructed as NO or NC contact units. The inter-circuit connection of these relays will be explained subsequently by reference to the function description. The pilot control unit 3 has an operating element, advantageously constructed as an electric drive motor M, and is supplied from the signalling unit 2 through two inter-necting conductors by means of which it is connected to the signalling unit 2 with driving control pulses IMI and IM2 depending on the presence of the control pulse I-601 which is associated with an instantaneous tilting moment value below the predefined tilting moment value and/or the presence of the control pulse I-602, which associated with an instantaneous tilting moment value between the predefined instantaneous tilting moment value and the maximum permissible tilting moment value, the pulses I-601 and I-602 supplied to the signalling unit 2. The pulse I-601 may exist simultaneously with the pulse I-602 up to a tilting movement range just preceding said maximum permissible tilting moment value, in which range, only the pulse I-602 is present. The direction of rotation of the motor M, is in each case determined by the pulses IMI and IM2 which act directly to drive the motor M.

The driving control pulse IMI or IM2 can be supplied alternatively to energy switching elements 301 or 302 respectively, having switch contacts 301′ and 302′ respectively and which are disposed in an energy conductor g, (Figure 3) connecting the electric motor M to an energy source Q and by means of which contact the supply of energy from the source Q to the motor M can be made or broken. The energy switching elements E1 and E2 in Fig. 3 correspond to the switching elements 301 and 302 respectively in Fig. 2. In this case the pulses IM1 and IM2 do not act directly to drive the motor M.

The pilot control unit 3 has a control circuit which is supplied with the driving control pulse IM1 or IM2 as starting pulse for the electric motor M, the control circuit having switching elements 301 to 304 (the elements 303 and 304 have switch contacts 303′ and 304′ respectively), automatically operated by the pilot control unit 3, and by means of which the electric motor may be switched off in accordance with a predefined time plane. In the embodiment illustrated in Fig. 2, four switching-off elements 301 to 304 are advantageously provided. These elements are actuated by a programme transmitter 305 driven through a spindle drive 312 which is in turn driven by the electric motor M. To this end, the switching elements 301 and 304 are constructed as limit

switches, actuated by the associated run-up curves 306*a* or 306*b* when the appropriate limiting position of the programme transmitter 305 is reached, while the switching element 302 and 303 are mechanically linked to sensing elements 310 or 311 which scan the cam contour 306 of the programme transmitter 305 during the translatory motion thereof effected by the electric motor thus actuating the contact elements 302′ or 303′. The numerals 301′ or 304′ refer to the appropriate contact elements of the switching elements 301 or 304 respectively. A control element 309 constructed as an electric resistor and having a switching element 308, constructed as insulating member, is connected to the programme transmitter 305. A wiper contact 307, stationarily disposed relative to the programme transmitter 305, varies its position on the control element 309 as the result of a translatory motion of the programme transmitter 305 effected by the electric motor M. The driving unit 4 has three hydraulic main regulating elements, namely 407, 408 and 409 which in turn are each provided with two driving means and are incorporated into the main hydraulic control circuit as valve units, actually and directly influencing the motions of the supporting beam 10, said main hydraulic control circuit in turn being not shown. These driving means are associated with the appropriate motion of the supporting beam 10. For example, the driving means 401 of the hydraulic main regulating element 407 for driving the supporting beam 10 in the sense of extending same and the driving means 404 of the hydraulic main regulating element 407 serves in the sense of retracting the supporting beam 10. The driving means 402 of the hydrualic main regulating element 406 is correspondingly associated with the anti-clockwise slewing motion and the driving means 405 of the main regulating element 408 is associated with the clockwise slewing motion while the driving means 403 of the hydraulic main regulating element 409 is associated with the inclining of the supporting beam 10 and the driving means 406 of the hydraulic main regulating element 409 is associated with the erection of the suporting beam 10.

To provide an optical display of the control pulse I-601, the signal indicating means 5 is provided with an optical indicating element 501 and with an optical indicating element 502 for displaying the control pulse I-602. However, an acoustic indication or a combination comprising of an optical and an acoustic indication may also be employed instead of an optical indication. The signal indicating means 5 can also be connected to recording means not shown, for example in the form of a pulse recorder. This enables the motions to be recorded for special purposes.

The presence of the control pulses is displayed in the signal indicating means 5 by colour coding of the kind usually employed in this technology.

For example, the control pulse I-601 is associated with colour green by means of the signal indicating means 501 and the control pulse I-602 is associated with the colour amber by the signal indicating means 502.

The method of operation of the apparatus according to the invention is as follows: If a control pulse I-601 (green) is obtained from the measured value transducer 13, the signal indicating means 501 will be illuminated in green and the relay coils R1″ of the relay R1, the relay coils R2″ of the relay R2 and the relay coils R4″ of the relay R4 will be biased and energised so that the current path e-i-g-R1-R1-M is provided for the control pulse I-601. The motor M is thus connected to the starting circuit but is as yet unable to start since the switching element 301 is open and the motor is therefore not provided with any voltage. This means that the main control unit 1 alone is effective and all motions of the supporting beam 10 can be traversed within a velocity range from zero to maximum, such maximum being determined by maximum pre-set velocity signal. To this end the programme transmitter 305 is in the position shown in full lines in Fig. 2.

If the signalling unit 2 is supplied from the measured value transducer 13 with a predefined pulse I-602 which characterises a predefined tilting moment value MK, the signal indicating means 502 will be illuminated an amber, the coil R3″ of the relay R3 will be energised and pull up its contacts. Accordingly, the current path e-i-R3 will be interrupted so that the relays R1 and R2 drop out. Dropping out of the relay R2 releases the current path a-R2-R2-M and the current path M-R1-R1-1-302′-c-b for the control pulse I-603 so that the electric motor M starts. Accordingly, the spindle drive 312 produces a translatory motion of the programme transmitter 305 so that the switching element 301 closes its contacts 301′. The translatory motion of the programme transmitter 305 moreover actuates the control element 309 so that additional electrical resistance is connected to the control circuit 170. This means that all motions of the supporting beam 10 with the exception of the retraction motion can now be traversed only at a reduced velocity.

If appropriate motions cause the supporting beam 10 to be once again removed from the tilting moment range determined by the pre-setting of the lower maximum velocity limit at which the control pulses I-601 and I-602 are present, the control pulse I-602 will disapear and its disappearance will have the following effects on the signalling unit 2: The relay R3 will once again drop out

so that the relays R1 and R2 will be energised. Accordingly, the motor M will rotate in the opposite direction of rotation since it is provided with the control pulse I-601 through the current path e-i-g-R1-R1-M, the current path M-R2-R2-301'-c-b being closed. The switching element 301 is once again opened in the restored starting position of the programme transmitter 305. This ensures that, if the supporting beam 10 is removed from said tilting moment range at which the control pulses I-601 and I-602 are present, the motions of said supporting beam may be performed in a velocity range which extends from zero to maximum. However, if the supporting beam 10 remains in said tilting moment range at which the control pulses I-601 and I-602 are present the signalling unit will have the following cundition: The relay R3 will be energised so that the relay R1 and R2 are dropped out. The control pulse I-602 will thus be provided with the current path a-R2-M-R1-R1-302'-c-b. This current path is maintained for as long as the sensing element 301 is actuated by the starting cam 306 of the programme transmitter 305 and the contacts 302' of the switching element 302 remain closed. The motor M stops when the sensing element 310 has mounted the cam contour 306 of the transmitter 305 to break the contact element 302', so that the programme transmitter 305 also stops. The transmitter 305 is thus stopped at a defined position. Accordingly, the additional control element 309 remains connected in the control circuit 170 the effect of which is that the motions of the supporting beam 10 can still only be traversed at a reduced velocity.

If the measured value transducer transmits only a pulse I-602 this means that the supporting beam 10 approaches a defined limiting tilting moment, namely the maximum permissble tilting moment. The circuit conditions of the control system in particular with regard to the signalling unit will be as follows in these conditions: Owing to the absence of the pulse I-601 the relay R4 drops out and the electric motor M will then be biased by the remaining control pulse I-602 through the following current paths: a-R2-R2-M-R1-R1-1-R4-R4-304-c-b. This condition means that the electric motor M moves the programme transmitter in the direction towards its limiting position and at the same time continuously switches the control element 309 into the control circut 170. Only when the extended limiting position of the programme transmitter 305 is reached will said programme transmitter operate the switching element 304 to interrupt the current path of the electric motor M. At the same time the wiper contact 307 will reach the switching element 308 so that the control circuit 170 will also be interrupted. As far as the main control unit 1 is concerned this means that only a single motion, namely the retracting motion, may be performed by the control element 116 so that the supporting beam 10 may be retracted to a position corresponding to the tilting moment at which the pulses I-601 and I-602 are present. When this has taken place the measured value transducer 13 will transmit a control pulse I-601 in addition to the control pulse I-602 so that the signalling unit 2 will assume the following circuit condition: The relay R5 will be energised since the current path for the control pulse I-601 is closed through the relay R5 and through the switching element 303. Energisation of the relay R5 causes the relays R1 and R2 to be energised so that a current path is provided for the control pulse I-601 to cause the motor to start in the opposite direction of rotation. This current path will be as follows: e-i-g-R1-R1-M-R2-R2-301-c-b. Immediately after the control pulse I-601 causes the electric motor M to start in the reverse direction of rotation, the contacts 304' of the switching element 304 will close, the switching element 308 is removed from the control circuit 170 and the traversing operation is completed when the switching element 303 is actuated by the cam contour 306 of the programme transmitter 305 through the scanning element 311. A defined position of the control element 309 is thus reached so that the motions of the supporting beam 10 may take place at reduced velocity due to the effect of the control circuit 170.

In this embodiment described with respect to its function, the control pulses I-601 and I-602 at the same time represent the driving pulses IM1 or IM2 respectively. Fig. 3 shows a circuit in which the control pulses and driving pulses are separated. In this case separate driving pulses IM1 or IM2 act on the solenoid coils of appropriate switching elements E1 or E2 respectively thus connecting an energy supply circuit g of the electric motor M to an energy supply source Q.

Fig. 4 shows by reference to a diagrammatic comparison the characteristics of the maximum possible velocities (velocity signals) relative to the tilting moment, thus indicating the advantage of the embodiment described herein relative to the two known control systems described initially. In Figure 4, the curve shown in broken lines and diminishing linearly and extending from a minimum torque to a maximum torque shows the envelope of the possible velocities with direct control and with a constant-value feed according to the two known systems. The stepped curve shown in dot-dash lines shows the envelope of the possible velocities when a flow restrictor is switched in in remote control operation and in accordance with the prior art. The envelope shown in double dot-dash

lines shows the possible velocities obtainable when the flow restrictors are engaged in accordance with the prior art and by direct operation. The solid curve on the other hand represents the envelope of the possible velocities in respect of the embodiment described herein. Comparison of the present embodiment with the prior art by reference to the diagrammatic comparison according to Fig. 4 clearly shows that a far greater range of maximum velocities of the individual motions is available in present embodiment.

In addition to the envelopes, showing the characteristics of the maximum possible velocities for the individual motions of the supporting beam (velocity signals), Fig. 4 also shows assumed examples for actually traversed velocities, the curves of the actually traversed velocities being shown as wavy lines of any desired kind, in the interests of clarification, and being characterised by identical lines as regards their association with the appropriate velocity signal characteristics. Fig. 4 therefore clearly shows that in the velocity signal curve shown in broken lines and referring to direct control in accordance with the prior art, using constant value feed and, in terms of quality indication for the associated control system according to the prior art merely provides a small triangular surface below this curve, the actually traversed velocity for a motion which may differ for the actually traversed velocity for some other motion, continuously approaches a disappearing value in the same way as the velocity signal value in the case of the maximum permissible tilting moment. Although in this control system according to the prior art the actually traversed velocities (shown as wavy curve) and relating to two motions may have a different appearance as regards their curves, it is a common feature of all velocity characteristics of this kind that they are disposed below the broken inclined straight line of the associated velocity signal characteristic and must reach a disappearing value at the maximum permissible tilting moment since all motions of the supporting arm are subject to the same velocity signal curve in this control system according to the prior art.

Fig. 4 furthermore shows that in the further control system according to the prior art and in which flow restrictors are switched into circuit the maximum possible velocity (velocity signal) is already at a higher velocity value in remote control operation.

For this reason alone, such a control system according to the prior art were to be preferred relative to the known direct control with constant value feed, since the area below the velocity signal curve associated with its control system and being a measure of the quality for the control, is substantially greater. This applies to an even greater degree to the known control system if it is used for direct operation since under these conditions the maximum possible velocity (velocity signal) may be even higher. The reason for the relative quality of the known control system compared with direct control with constant-value feed according to the prior art is due to the fact that despite a change of the tilting moment to unfavourable values, the velocity signal is not reduced until the tilting moment reaches a predefined value but is then reduced to such an extent that any further operation of the supporting beam motion accompanied by a further approach to the maximum permissible tilting moment will not involve any risk. Attempts will naturally be made to make the area below the left-hand step of the stepped curve of the known control system as large as possible and to make the drop of velocity signal as steep as possible so that the largest possible velocity signal is obtained for as long as possible, that is to say to the highest possible tilting moment values or, expressed in other words, in order to retain a high velocity reserve for the highest possible tilting moments so that such velocity reserve can be utilised when required without it being necessary in each case to perform the traversing motions at such high velocity.

The known control system, operating with the engagement of flow restrictors, also suffers from the disadvantage, recognisable by reference to Fig. 4, that the sudden changeover from a high velocity signal to a low velocity signal when the predefined tilting moment value is reached may be accompanied by the dangerous acceleration forces which have a detrimental effect on the supporting beam in the manner already described. These unfavourable effects will be the greater the higher the value of the velocity signal in the range prior to reaching the predefined tilting moment as well as in accordance with the degree to which the velocity signal would have to be reduced.

As will be apparent from the solid curve in Figure 4, the velocity signal can be used in the same favourable manner and with the highest possible value and at the highest possible tilting moment ranges and, on reaching a predefined tilting moment value, making it possible to change over to a lower velocity signal so that this aforementioned velocity value, which may still be relatively high according to the present embodiment, may be used for approaching the maximum permissible tilting moment without having to tolerate the disadvantages of the known control system which operates by engagement of the flow restrictor. With the present embodiment the changeover from the high velocity signal to the reduced velocity signal takes place forcibly, automatically and continuously (as indicated by the slope in Figure 4). The disadvantages of the supporting beam and for

goods and persons disposed thereon, namely due to acceleration forces cannot occur in practice since in the case of the present embodiment these accelerations are eliminated by the continuous reduction of the velocity signal. Switching off at the moment at which the maximum permissible tilting moment is reached may occur suddenly since it is possible to control the velocity signal for the motions of the supporting beam so that a sudden switching off of the individual motional velocities actually traversed when the maximum permissible tilting moment is reached, do not involve any risk for the supporting beam, since, in accordance with the reduced velocities actually traversed in accordance with the reduced velocity signal, the acceleration forces are no longer sufficient to cause damage. Also, a further shift of the changeover operation, not illustrated in Fig. 4 is allowed for namely from a high velocity signal to a reduced velocity signal due to the forcible continuous reduction of the velocity signal.

By virtue of the embodiment described above a higher initial maximum possible velocity can be employed than in the case of the prior art, as will be apparent from Figure 4. This is because the reduction of the initial maximum possible velocity to the subsequent lower maximum possible velocity does not take place abruptly as in the case of the prior art but is gradual as indicated by the slope in Figure 4. The subsequent maximum possible velocity may also be higher than in the case of the prior art.

Although the present embodiment operates with electric circuit elements, the invention may also be performed in identical manner by components operating with hydraulic or pneumatic pulse transmission and corresponding to the aforementioned electric components and being associated in corresponding manner with each other. Components corresponding to such electrical components have not been shown since their construction function and method of use in analogy with the illustrated electrical components is familiar to the expert who can choose the pulse carrier or energy medium in accordance with the requirements of the individual case and the prevailing design conditions and who may perform the invention by other combinations of individual features or exchange them for identically acting other means.

WHAT WE CLAIM IS:—

1. Apparatus for controlling the velocity of motion of a supporting beam, such as the ladder nest of an extensible turntable ladder, the extensible mast of a telesoter or of a longitudinally adjustable crane arm, the length and position of which are variable in space, in response to the tilting moment produced by the instantaneous values of the length of the supporting beam, the inclination of the supporting beam and a supplementary weight loading the supporting beam, in such a manner that in operation of the supporting beam, when a predefined value of the tilting moment is reached, a first predefined value of the maximum possible velocity of at least one of the motions changing the length or the position of the supporting beam in space is increased or decreased to a second predefined maximum possible velocity value in dependence upon the direction of motion of the supporting beam, to cause a decrease or an increase in the tilting moment of the supporting beam, the transition from said first to said second predefined value of velocity being performed in a predefined time interval, the momentary velocity of the supporting beam being adjustable at will between zero velocity and the existing maximum possible velocity value.

2. Apparatus according to claim 1, wherein means are provided to vary a pulse for operating means for driving the beam in at least one motion of the beam in response to the attainment of a predefined value of the tilting moment.

3. Apparatus according to claim 2, wherein the means for varying the operating pulse for the driving means is so constructed that after a predefined value of the tilting moment has been reached, the velocity for further setting up motion of the supporting beam is lower than the existing maximum possible velocity.

4. Apparatus according to claim 3, wherein means are provided to prevent one or more operating pulses from being fed to the driving means for one or more of said motions to operate such driving means in a sense to increase the tilting moment when a predefined tilting moment value is reached.

5. Apparatus according to claim 3 or claim 4, wherein means are provided to permit one or more operating pulses for the driving means to be fed thereto when a predefined tilting moment which is lower than the maximum permissible tilting moment has been reached so that the restoring motions of the supporting beam can proceed at a velocity which corresponds to the maximum possible velocity.

6. Apparatus according to any one of claims 2 to 5 including a measured value transducer which provides a pulse to control the means for varying the operating pulses, the characteristics of the control pulse depending on the instantaneous value of the supporting beam length, the supporting beam inclination and the supplementary weight acting on the support beam.

7. Apparatus according to claim 6, wherein the control pulse also depends on the angular position of the supporting beam relative to

an axis perpendicular to the axis for said inclination of the supporting beam.

8. Apparatus according to claim 6 or claim 7, wherein the transducer is constituted by a tilting moment balance.

9. Apparatus according to any one of claims 2 to 8, wherein the means for varying the operating pulses for the driving means depend upon at least two control pulses.

10. Apparatus according to claim 9, wherein one of the control pulses exists from the attainment of the predefined tilting moment up to the attainment of the maximum permissible value of the tilting moment and another control pulse exists up to a value just below such maximum permissible value.

11. Apparatus according to any one of claims 2 to 10, wherein the means for varying the operating pulse(s) for the driving means is so constructed that the velocity of the restoring motions of the supporting beam can be changed from zero to the maximum possible value and vice versa for setting up the motions of the supporting beam, when a control pulse which is associated with a momentary value of the tilting moment which is lower than the maximum permissible tilting moment, is supplied thereto.

12. Apparatus according to any one of claims 2 to 10, wherein the means for varying the operating pulse for the driving means are constructed so that the motional velocity of the supporting beam can be changed from zero to a first predetermined value, which is lower than the maximum permissible value, and vice versa, if both a first control pulse associated with a first momentary value of the tilting moment below the maximum permissible tilting moment and a second control pulse associated with a second momentary value of the tilting moment between the first predetermined tilting moment value and the maximum permissible tilting moment are supplied thereto.

13. Apparatus according to any one of claims 2 to 10, wherein the means for varying the operating pulse for the driving means is constructed so that if only one control pulse associated with an instantaneous tilting moment value between the predefined tilting moment and the maximum permissible tilting moment is supplied, the velocity can be automatically changed from zero value to a preset value which is proportional to the maximum possible velocity value.

14. Apparatus according to any one of claims 6 to 10, when read as appendant to claim 6, wherein the means for varying the operating pulse for the driving means includes a signalling unit, a pilot control unit and a main control unit, such units being operable under the control of the measured value transducer.

15. Apparatus according to claim 14, wherein the signalling unit includes a control circuit for at least one switching element which is associated with the pilot control unit.

16. Apparatus according to claim 15, wherein the signalling unit is constructed to respond to fluidic pulses.

17. Apparatus according to claim 15, wherein the signalling unit is constructed to respond to pneumatic pulses.

18. Apparatus according to claim 15, wherein the signalling unit is constructed to respond to hydraulic pulses.

19. Apparatus according to claim 16, wherein the signalling unit is constructed to respond to electrical pulses.

20. Apparatus according to any one of claims 15 to 19, wherein the signalling unit includes relays which are operable in response to the control pulses.

21. Apparatus according to claim 20, wherein the signalling unit is provided with relays constructed as NO or NC contact units.

22. Apparatus according to claim 20 or 21, wherein at least five relays are provided and are interconnected by electric current paths.

23. Apparatus according to claim 14 or 15 when read as appendant to claim 12, wherein the signalling unit has a first relay the contact of which is in a pulse conductor for said first control pulse, such pulse conductor branching into two parts downstream of the contact of said first relay, the relay coils of a second and a third relays each being disposed in one of said parts, the contacts of said second and third relays being serially connected in a first supply conductor for the supply of the first control pulse to a drive means of the pilot control unit, the contact of the first relay being in a pulse conductor for said second control pulse, the contacts of the second and third relays being also serially connected in a second supply conductor for the supply of the second control pulse to the drive means of the control unit.

24. Apparatus according to claim 23, wherein the first relay is so constructed that in the absence of the second control pulse the contact of the first relay provides free passage for the pulse switched by such contact as part of the pulse conductor for the first control pulse while the second and third relays are so constructed that their contacts provide free passage as part of the first supply conductor and for the pulses switched by the such contacts if the first control pulse is present and in the absence of the first control pulse and are closed in their function as parts of the second supply conductor, the first control pulse being directly supplied to the contact for the switched pulse of the second relay and the second control pulse being directly supplied to the contact for the switched pulse of the third relay.

1361832 COMPLETE SPECIFICATION
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Sheet 2

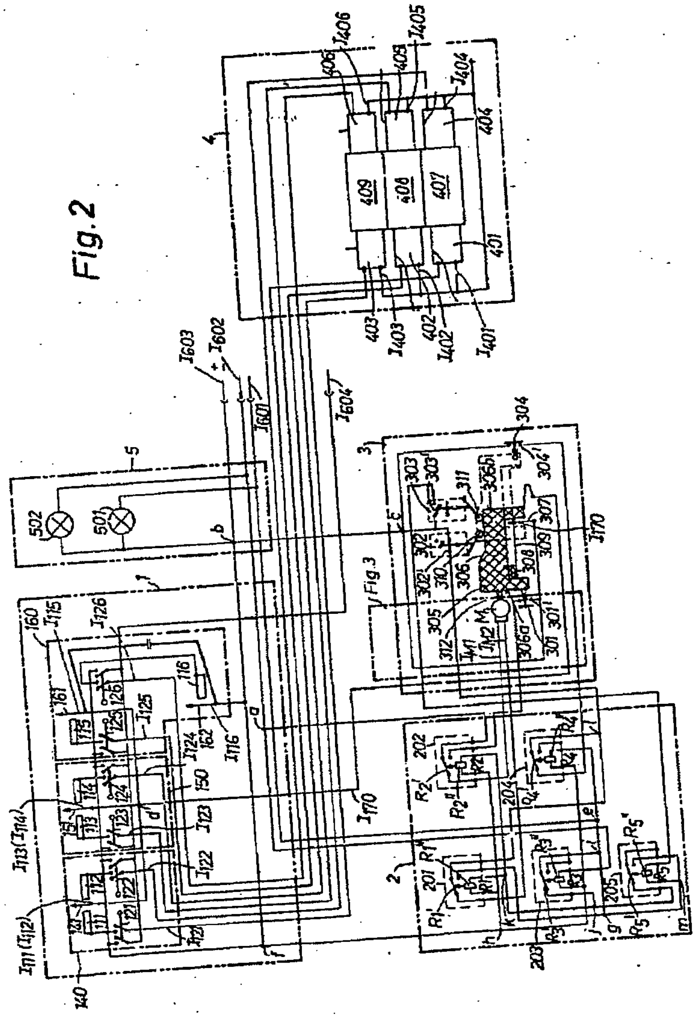

Fig. 2

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Sheet 3

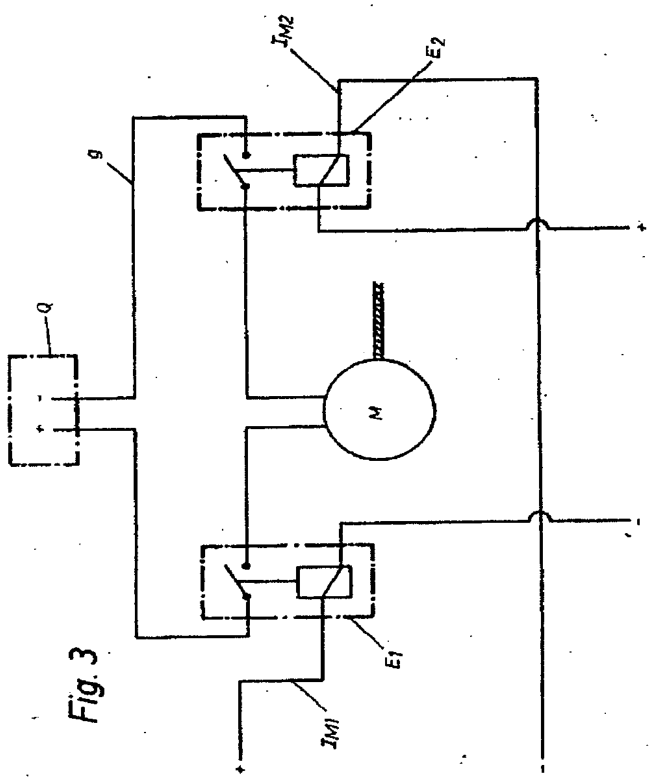

Fig. 3

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Sheet 4

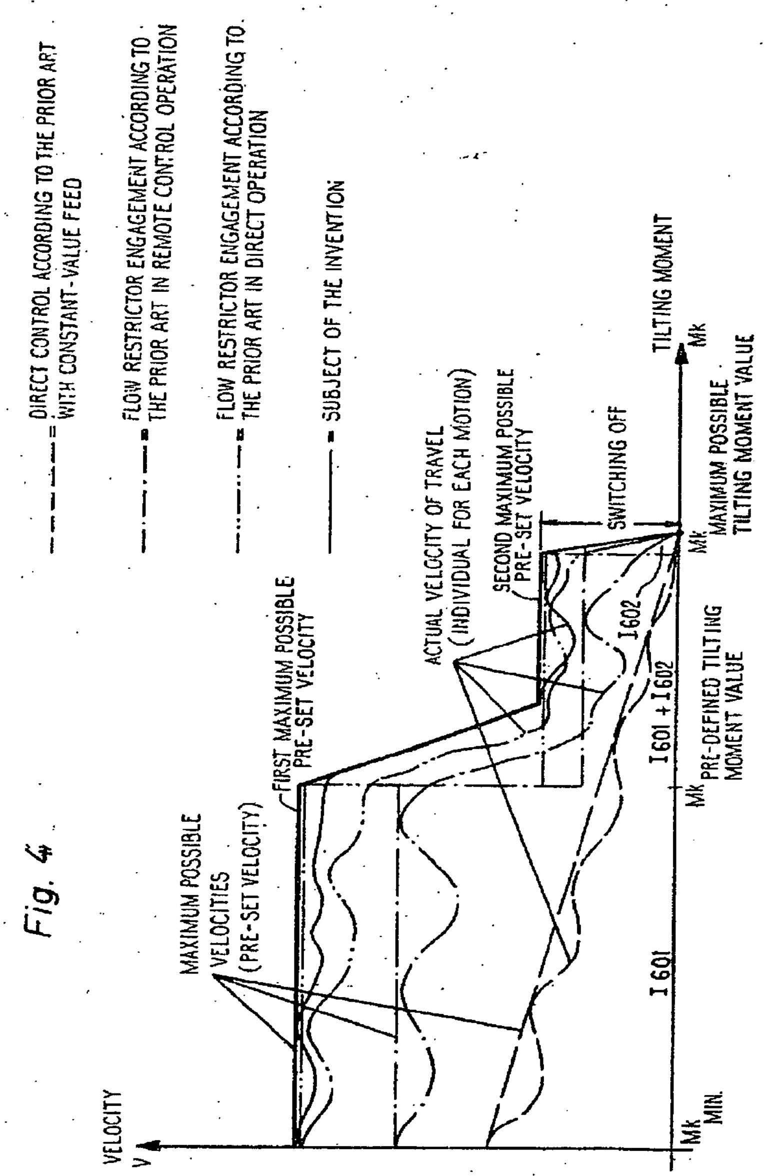

Fig. 4